Extended Atmospheres of Outer Planet Satellites and Comets

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16. Abstract

The new cometary hydrogen particle-trajectory model, completed last year, has been used successfully to analyze observations of Comet P/Encke. The Pioneer Venus Orbiter Ultraviolet Spectrometer observed the comet at 1216Å (hydrogen Lyman-α) on 15 April 1984, when the comet was .58 AU from the Sun and 1.02 AU from Venus. The analysis implies a production rate at .58 AU of 3.3×10^{28} s^{-1} of the water molecules which photodissociate to produce the observed hydrogen.

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I. Program of Research for the First Quarter

Research activities during the first quarter have concentrated on the cometary portion of this project. A collaborative effort with A.I.F. Stewart from LASP of the University of Colorado has been established for analyzing cometary observations made with the Pioneer Venus Orbiter Ultraviolet Spectrometer. The AER particle-trajectory model is ideally suited to analyzing this type of data.

Analysis of Pioneer Venus Observations of Comet P/Encke

The Pioneer Venus Orbiter Ultraviolet Spectrometer (PVOUS) observed Comet P/Encke at 1216 Å (hydrogen Lyman-α) on 15 April 1984, when the comet was 0.58 AU from the Sun and 1.02 AU from Venus. The field of view of the instrument made 270 passes across the coma, taking samples every 4.9×10^5 km along a swath whose width was 3.7×10^6 km. The path of the swath made an angle of about 42° with the comet-sun line as projected on the sky plane. The maximum observed signal was 1.30 kR, including an interplanetary background of 0.43 kR. The distortion of the hydrogen coma due to solar radiation pressure was evident. The fully calibrated and reduced data were provided to us by A.I.F. Stewart.

These data have been analyzed with the AER particle-trajectory model based on the production of H atoms by photodissociation of H_2O and OH. This model, developed under previous NASA contracts, calculates exact atom trajectories in three dimensions taking into account both variable solar radiation pressure and solar gravity, and includes the fully time-dependent spatially extended random ejection directions of photodissociated atoms and radicals.

Table 1 lists the numerical parameters of the model run appropriate to the P/Encke observations. The photodecay lifetimes shown in Table 1 are varied appropriately as the square of the heliocentric distance, and the initial H_2O velocity is given in the model as $0.58\ r_H^{-1/2}$ km s^{-1} (Delsemme 1982). The shape of the solar Lyman-α profile used both for the radiation pressure acceleration as well as for the Lyman-α emission rate, both of which are heliocentric velocity dependent, was taken from Lemaire et al. (1978). The absolute solar Lyman-α emission rate at the time of the observation was provided by Stewart (1984) from Solar Mesospheric Explorer data. The H_2O production rate was assumed to vary as the inverse square of the heliocentric

Table 1

NUMERICAL MODEL PARAMETERS
(R_H = 0.58 AU)

$T(H_2O)$	=	2.9×10^4s
T(OH)	=	9.6×10^4s
T(H)	=	3.4×10^5s
$V(H_2O)$	=	0.76 km/s
V(OH)	=	1.8 km/s
V(H)	=	8, 20 km/s
VENUS-COMET-SUN ANGLE	=	43.8°
G-FACTOR	=	3.74×10^{-3} photons/atoms/s
$Q(H_2O)$	~	R_H^{-2}

distance of the comet, as is appropriate for comet-sun distances $\leq$0.7 AU (Delsemme 1976).

Figure 1 shows a comparison of the observed Lyman-α scans with the modeled scan. The model output includes the trapezoidal slit function appropriate to the PVOUS data. The model analysis implies a water production rate of 3.3×10^{28} molecules s^{-1} from Comet P/Encke at the time of the observation. This value is in very good agreement with the OH production rates of P/Encke measured and compiled by A'Hearn, Feldman and Stewart (1984). These results were presented at the meeting of the Division of Planetary Sciences of the American Astronomical Society in Kona, Hawaii in October (Combi, Stewart and Smyth 1984).

II. Program of Research for the Second Quarter

Research activities during the second quarter in the area of comets will concentrate on initial steps toward the development of the carbon and oxygen models and writing a paper with A.I.F. Stewart on the PVOUS Comet P/Encke observations. Initial development of the carbon and oxygen models will entail an evaluation of the photochemistry of CO_2, CO and H_2O relating to the production of C and O atoms.

Research activities in the Saturn system will be continued in the second quarter. The Titan hydrogen torus model, which was improved to include the spatial lifetime of H atoms in the Saturn magnetosphere last year, will undergo further testing in preparation for modeling the Lyman-α data acquired by the Voyager 1 UVS instrument. This Lyman-α data is currently being properly formatted by D.E. Shemansky, with whom a collaborative effort has been established, for use in this modeling analysis.

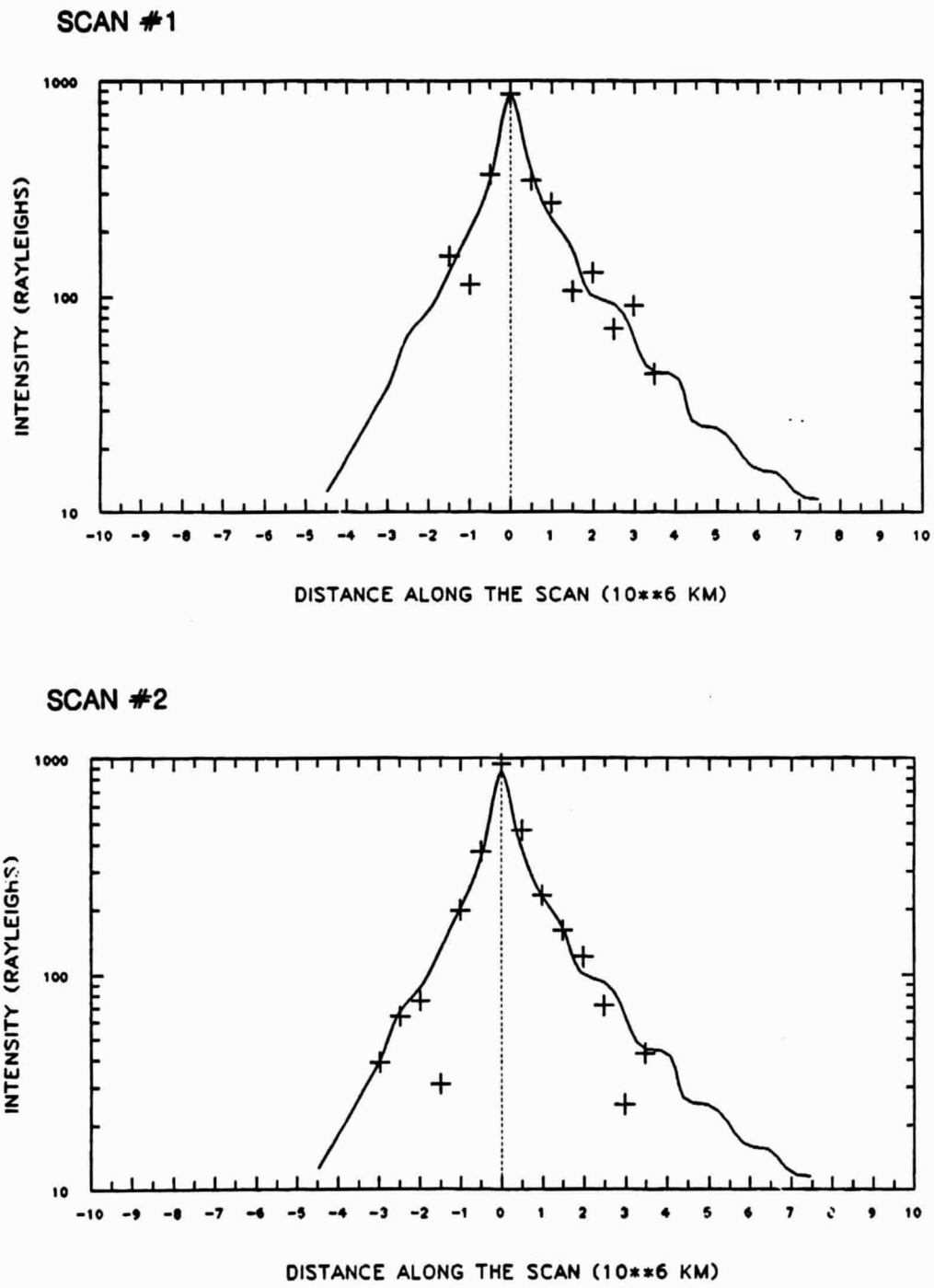

Figure 1. Model-Data Comparison for Pioneer Venus Observations of Hydrogen Lyman-α in Comet P/Encke.

The two scans taken six hours apart on 15 April 1984 are shown as the crosses in the plots above. The solid lines are for the best fit particle-trajectory model run as discussed in the text.

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